DESIGN SPECIFICATION
FOR
EOD - LARSYS/STATISTICS AND DATA TRANSFORMATION PROCESSORS MODIFICATION

Job Order 71-695

(TIRF 77-0034)

(E80-10177) DESIGN SPECIFICATION FOR EOD-LARSYS/STATISTICS AND DATA TRANSFORMATION PROCESSORS MODIFICATION (Lockheed Electronics Co.) 48 p HC A03/MF A01 CSCL 05B G3/43

N80-28778

Unclas 00177

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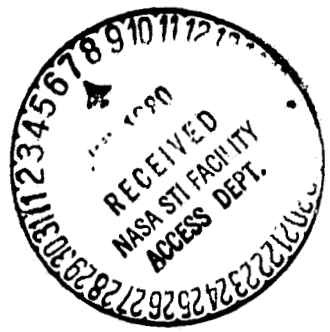
Contract NAS 9-15200

For

EARTH OBSERVATIONS DIVISION

SPACE AND LIFE SCIENCES DIRECTORATE



National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

October 1977

LEC-11357

JSC- 13665

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LEC- 11357

CONTENTS

1. SCOPE

This document contains the design specifications and description of the modifications made to the Statistics and Data Transformation processors of the EOD-LARSYS system. The requirements to be satisfied are specified in the task agreement 77-3 titled, "LARSYS/ Data Transformation Processor Modification" originally dated 6/17/77 and revised 9/12/77 and the "EOD-LARSYS System Design Modifications for PCG Transformation Requirements" memo, dated 8/24/77. The modification requirements were provided by the Research, Test, and Evaluation Branch (RT&E) of the Earth Observations Division (EOD), of NASA/JSC.

2. APPLICABLE DOCUMENTS

The following documents will serve as references:

- EOD-LARSYS Users' Document, LEC-3984, March 1977
- Task Description and Agreement, dated 6/17/77, "LARSYS/Data Transformation Processor Modification"
- Symat, Covar, Test Procedures for Matrix Calculations by W. L. Morris, C. L. Wiginton, and D. K. Lowell, Report #17, Contract NAS 9-12777, dated October 1972
- Principal Component Greenness (PCG) Transformation Requirements for LARSYS by R. A. Abotteen
- EOD-LARSYS System Design Modifications for PCG Transformation Requirements, dated August 24, 1977

3. SYSTEM DESCRIPTION

This document describes the changes that will be implemented into the existing Statistics and Data Transformation processors to generate and output an optional greenness and/or Principal Component Greenness (PCG) Image. The basic image will continue to be a multi-temporal/multi-pass data tape. The result is a transformation which will assist in LACIE-type classification. The user will be provided the options of:

a. Filtering raw or sun angle corrected data vectors in the Statistics processor,

b. Using sun angle corrected data in the DATA - Transformation processor to compute a greenness and/or principal component image.

3.1 HARDWARE DESCRIPTION

N/A

3.2 SOFTWARE DESCRIPTION

3.2.1 SOFTWARE COMPONENT NO. 1 (STAT)

The Statistics processor, STAT, will be modified to calculate on option the mean and covariance matrices from filtered and/or sun angle corrected data. These options will be provided if the new control cards 'SUNANG' and 'OPTION WATER' or 'OPTION TASSEL' are input by the user.

If the 'SUNANG' control card is present, the channel-oriented sun angle bias and gain correction factors will be applied to the corresponding channel component of the raw data vector.

$$X_T(I) = SAGAIN(I) * X_R(I) + SABIAS(I)$$

where $X_T(I)$ = the I-th channel component of the sun angle corrected data

SAGAIN(I) = the sun angle gain correction factor for the I-th channel

SABIAS(I) = the sun angle bias correction for the I-th channel

X_R(I) = the I-th channel component of the raw data

The user will have the option of applying one of the following filters to the raw or sun angle corrected data vectors:

a. Water filter - initiated by the input of the 'OPTION WATER' control card. (see Appendix A.2 for the 'Water' filter test)

b. Tassel Cap filter - initiated by the input of the 'OPTION TASSEL' control card. (see Appendix A.2 for the 'Tassel Cap' filter test)

3.2.1.1 Linkages

The STAT processor uses the FORTRAN-V compiler, Univac software system routines, EOD-LARSYS utility routines, and the COMBK4 and STBASE common blocks.

See Appendix A for the modifications to be made to the individual subroutines.

3.2.1.2 Interfaces

The STAT processor interfaces with the EOD-LARSYS executive routine, MONTOR.

3.2.1.3 Inputs

The processor requires an MSS data tape (DATAPE). The default tape assignment is the logical unit C (Fortran Unit 3).

- NEW CONTROL CARDS

Keyword	Parameter	Function
(col. 1)	(col. 11-72)	
SUNANG	Tape (Default - no sun angle correction applied)	Sun angles will be extracted from the ERIPS 'unload' MSS image tape.
SUNANG	$n_1, \ldots, n_j$ (Default- no sun angle correction applied	n_i = sun angle for pass i, $1 \leq i \leq 8$. Sun angles are integer numbers which are $5 \leq n_i \leq 85$.
B-MATRIX	Cards (Default - none)	The B-Matrix will be found on the cards immediately following this control card.
B-MATRIX	File (Default - none)	The subroutine BMFIL will be called to read the B-Matrix off of the file, BMFILE
THRESHOLD	$a_1, \ldots, a_j$ (Default - for 'Tassel Cap' filter, $a_1 = 100$ $a_2 = 8.0$ $a_3 = 6.0$ $a_4 = 10.0$ $a_5 = 35.0$ for the 'Water' filter, $a_1 = 43.0$ $a_2 = 12.0$)	The a_i's are decimal (floating point) numbers, separated by commas; if the user requested a 'Tassel Cap' filter, j must be equal to 5; if the 'Water' filter was requested, j must be equal to 2.

Keyword	Parameter	Function
BIAS	$b_1, \ldots, b_4$ (Default - $b_i = 0.0$)	The b_i's are decimal (floating point) numbers, separated by commas; the bias values will be used only if the 'Tassel Cap' filter is requested.
OPTION	Tassel (Default - none)	Initiates the Tassel Cap filtering.
OPTION	Water (Default - none)	Initiates the Water filtering.

- MODIFIED CONTROL CARD

Keyword	Parameter	Function
(col. 1)	(col. 11-72)	
CHANNELS	Data = $l_1, \ldots, l_n$, (Default - n = 30), Filter = $m_1, \ldots m_j$ (Default - none)	The l_i's and m_i's are integer channel numbers, separated by commas; they must be a subset of the MSS Image tape. The l_i's will be used in the generation of the mean and covariance matrix. The m_k's are the channels to be used in the user-requested filter process. If the 'Tassel Cap' filter was requested, j must be equal to 4 (based on 4 channels/pass). If the 'Water' filter was requested j must be equal to 2.

3.2.1.4 Outputs

The Statistics processor will continue to output the statistics on the default or user-requested SAVTAF file. The default logical unit is A (Fortran unit 1) and the default file number is 1.

The line printer and file output remain unchanged.

3.2.1.5 Storage Requirements

TDB

3.2.1.6 Description

The Statistics processor, STAT, of the EOD-LARSYS system will be modified to optionally calculate and output on SAVTAP a mean vector and mixture covariance matrix $\sum_x$ calculated from the optionally filtered raw or sun angle corrected data vectors. Several new control cards will be implemented in the STAT processor to determine if the above calculations are to take place. The presence or absence of the 'SUNANG' control card will determine if raw or sun angle corrected data vectors are to be used in the generation of the above matrices. The user will also have the option of filtering out some data vectors from the above calculations by the presence or absence of the 'OPTION TASSEL' or 'OPTION WATER' control card.

The new mixture covariance matrix will be used in the DATA-TR processor to generate the mixture covariance matrix of the Green Image bands.

3.2.1.7 Flowchart

N/A

3.2.1.8 Listing

TBD

3.2.2 SOFTWARE COMPONENT NO. 2 (DATA-TR)

The Data Transformation processor, DATA-TR, of the EOD-LARSYS system will be modified to perform an optional Green Image and/or Principal Component Greenness (PCG) Image transformation(s). The addition of a SUNANG control card allows for the sun angle gain and bias correction factors to be applied to the raw data before the above mentioned transformation(s). The Green image and/or PCG image will be additional to the current options for performing transformations in DATA-TR.

3.2.2.1 Linkages

The DATA-TR processor uses the Fortran-V compiler, Univac software system routines, EOD-LARSYS utility routines, and the INFORM, TRBLCK, and GLOBAL common blocks.

3.2.2.2 Interfaces

The DATA-TR processor interfaces with the EOD-LARSYS executive routine, MONTOR.

3.2.2.3 Inputs

The processor requires an MSS data tape (DATAPE). The default tape assignment is the logical unit C (Fortran Unit 3).

- NEW CONTROL CARDS

Keyword (col. 1)	Parameter (col. 11-72)	Function
OPTION	Green (Default - Green image not generated for output)	The Green image will be generated and output.

Keyword (col. 1)	Parameter (col. 11-72)	Function
OPTION	PCG (Default - No Principal Component Green Image output)	The PCG image will be generated and output.
FORMAT	Universal (Default - Universal)	The transformed data will be output in the Universal format.
FORMAT	LARSYS (Default - Universal)	The Transformed data will be output in the LARSYS II format.
SUNANG	Tape (Default - no sun angle correction applied)	Sun angles will be extracted from the ERIPS "unload" MSS image tape.
SUNANG	$n_1, \ldots, n_j$ (Default - no sun angle correction applied)	n_i = sun angle for pass i, $1 \leq i \leq 8$. Sun angles are integer numbers, $5 \leq n_i \leq 85$.
TRFORM	OUTPUT/UNIT=N, FILE=M (Default - N=14, M=1)	N = the tape's Fortran logical unit number that the new image of transformed data is to be output on. M = the file number that the new image is to be output on. If both Greenness and PCG are to be generated, the former image will be on file M and the latter image on file (M+1)

3.2.2.4 Outputs

The Data-Transformation processor will continue to output the transformed/rescaled data on the default or user-requested TRFORM file and/or unit, in either the Universal or LARSYS II format. The default logical unit is L (Fortran unit 14) and the default file number is 1.

The two additional optional transformed/rescaled data output are Green Image and Principal Component Greenness (PCG) Image.

3.2.2.5 Storage Requirements

TBD

3.2.2.6 Description

In order to allow the user to optionally generate and output a raw or sun angle corrected Green Image and/or PCG Image, several existing subroutines will be modified. In addition, several new subroutines and formulas will also be implemented into the Data Transformation processor.

The scaling parameters MAX, MIN, and CON calculated in KBTRAN will be derived from the sun angle corrected SAVTAP subclasses' mean and standard deviation terms when the sun angle correction option is requested.

The new subroutine GETGCV will be called to pull out the mixture covariance matrix Σ_x from SAVTAP. The new subroutine PCSUNF will provide the sun angle correction parameters.

The green image will be generated as follows:

$$\vec{G} = A\vec{x} + \vec{b}$$

where $\vec{G}$ = transformed green image vector

$\vec{x}$ = raw (or sun angle corrected) data vector

A = matrix in which each row contains the L1, L2, or user-specified Kauth greenness vector (stored internally in BMAT in the 'B-Matrix' format)

$\vec{b}$ = default or user-specified bias vector

The covariance matrix Σ_X will be used to generate the Green Image's covariance matrix Σ_G according to the formula:

$$\Sigma_G = A \ \Sigma_X \ A^T$$

where Σ_G = the Green Image's covariance matrix

Σ_X = the (optionally) filtered raw or sun angle corrected covariance matrix calculated in STAT

A^T = the transpose of the A Transformation matrix

The newly generated covariance matrix Σ_G will then be input into the new subroutine PCMMAT to derive an nxn unitary matrix PCM.

The PCG image will then be generated as follows:

$$\vec{P} = (PCM) \ \vec{G}$$

where $\vec{P}$ = n-dimensional PCG image vector (n - number of passes; i.e., LANDSAT acquisitions)

PCM = an nxn unitary matrix obtained from PCMMAT

$\vec{G}$ = n-dimensional green image vector

The currently available options for re-scaling the transformed data to a range of 0-255 for output will be unchanged. All re-scaling options will be available to be applied to the green image and/or the PCG image created as a result of these modifications.

3.2.2.7 Flowchart

N/A

3.2.2.8 Listing

TBD

APPENDIX A

APPENDIX A

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A.1 SOFTWARE SUBPROGRAM NO. 1 (SETUP1)

The modifications to the subroutine SETUP1 will result in the reading and decoding of the following additional control cards:

a. SUNANG
b. B-MATRIX
c. THRESHOLD
d. BIAS

Two new additional parameters will be read and decoded from the 'OPTION' control card. They are:

a. OPTION TASSEL
b. OPTION WATER

The format of the 'CHANNELS' control card will be modified to be:

CHANNELS DATA = $d_1, \ldots, d_n$, FILTER = $f_1, \ldots, f_j$

where the d_i's and f_k's are integers.

Several new flags will be initialized in the subroutine to be tested in the LEARN subroutine. The flags that will be placed in the STBASE common block are:

a. SAKEY - sun angle key - if on, apply the sun angle correction factors to the current raw data.

b. FKEY - filter key - if FKEY=0, no filtering will be applied to the data vectors; if FKEY=1, the Water filter will be applied to the data vectors; if FKEY=2, the Tassel Cap filter will be applied to the data vectors.

The following dimensioned variables will be initialized in this subroutine to be used in the LEARN subroutine:

a. SSUNAG - the sun angles read from the 'SUNANG' control card

b. BIAS - the bias vector to be used in the Tassel Cap filtering process.

c. TH - the threshold values to be used in the 'Tassel Cap' or 'Water' filtering process.

d. BMAT - the matrix (in the B-MATRIX format) to be used in the Tassel Cap filter test.

e. FCHN - the channels of the data vector that will be used in the user-requested filter test.

A.1.1 Linkages

SETUP1 is called by the Statistics processor driver program, STAT.

The following subroutines may be called by SETUP1: NXTCHR, FIND, NUMBER, BMFIL, and FLTNUM.

A.1.2 Interfaces

SETUP1 references the following common blocks: STBASE and GLOBAL.

A.1.3 Inputs

The calling sequence to SETUP1 remains unchanged.

- NEW CONTROL CARDS

Keyword (col. 1)	Parameter (col. 11-72)	Function
SUNANG	Tape (Default: no sun angle correction applied)	Sun angles will be extracted from the ERIPS unload MSS image tape.
SUNANG	$n_1, \ldots, n_j$ (Default: no sun angle correction applied)	n_i = sun angle for pass i, $1 \leq i \leq 8$. Sun angles are integer numbers which are $5 \leq n_i \leq 85$.

Keyword (col. 1)	Parameter (col. 11-72)	Function
B-MATRIX	Cards (Default: none)	The B-Matrix will be found on the cards immediately following this control card.
B-MATRIX	File (Default: none)	The subroutine BMFIL will be called to read the B-Matrix off of the file, BMFILE.
THRESHOLD	$a_1, \ldots, a_j$ (Default: for 'Tassel Cap' filter, $a_1 = 100.$ $a_2 = 8.0$ $a_3 = 6.0$ $a_4 = 10.0$ $a_5 = 35.0$ For the 'Water' filter, $a_1 = 43.0$ $a_2 = 12.0$	The a_i's are decimal (floating point) numbers, separated by commas; if the user requested a 'Tassel Cap' filter, j must be equal to 5; if the Water filter was requested, j must be equal to 2.
BIAS	$b_1, \ldots, b_4$ (Default: $b_i = 0.0$)	The b_i's are decimal (floating point) numbers, separated by commas; the bias values will be used only if the 'Tassel Cap' filter is requested.
OPTION	Tassel (Default: none)	Sets the flag (FKEY=2) to apply the 'Tassel Cap' filter to the data vectors.
OPTION	Water (Default: none)	Set the flag (FKEY=1) to apply the 'Water' filter to the data vectors.

- MODIFIED CONTROL CARD

The following control card will replace the current 'CHANNELS' format.

Keyword (col. 1)	Parameter (col. 11-72)	Function
CHANNELS	Data = l_1, . . ., l_n, (Default: n = 30), Filter = m_1, . . ., m_j (Default: none)	The l_i's and m_k's are integer channel numbers, separated by commas; they must be a subset of the MSS Image tape. The l_i's will be used in the generation of the mean and Covariance matrix. The m_k's are the channels to be used in the user - requested filter process. If the 'Tassel Cap' filter was requested, j must be equal to 4 (based on 4 channels/pass). If the 'Water' filter was requested, j must be equal to 2.

A.1.4 Outputs

Two new additional line printer outputs will be implemented into the subroutine SETUP1:

a. If the Tassel Cap filter was requested but the number of input filter channels is not equal to four or the number of input threshold values is not five, the following error message will be output:

'The number of input filter channels or threshold values are not compatible with the filter option requested-Terminate Execution'.

b. If the 'Water' filter was requested but the number of input filter channels or threshold values is not two, the above error message will be output.

c. If the 'Tassel Cap' filter was requested but the user did not input the 'B-MATRIX' control card or if the dimension of the B-Matrix (KAUTH filter matrix) is not 4 x 4 then the following error message will be output:

'The B-Matrix was not input or was not of the right dimension - Terminate.'

A.1.5 Storage Requirements

TBD

A.1.6 Description

The purpose of the SETUP1 subroutine is to read and analyze all of the input processor control cards as well as their parameters.

As a result of the modifications to SETUP1, the user will be given the options to:

a. Apply the sun angle correction factors to the raw data vectors,

b. Apply a 'Tassel Cap', 'Water', or no filter to the raw or sun angle corrected data vectors, and

c. Calculate and output the filtered raw or sun angle corrected mean and covariance matrix computed over the image data set.

The covariance matrix will be used in the DATA-TR processor to generate a Principal Component Greenness Image.

A.1.7 Flowchart

N/A

A.1.8 Listing

TBD

A.2 SOFTWARE SUBPROGRAM NO. 2 (LEARN)

The functions to be provided by the subroutine LEARN are to enable the user to calculate the mean vector and covariance matrix from filtered raw or sun angle corrected data vectors. The new flag SAKEY will be tested to determine if the sun angle correction factors are to be applied to the raw data vectors. The value of the new flag FKEY will determine if Water, Tassel Cap, or no filter is to be applied to the data vectors.

A.2.1 Linkages

LEARN is called by STAT, the driver program for the STATISTICS processing.

The following subroutines may be called by LEARN: TAPHDR, PCSUNF, FSBSFL, CMERR, LAREAD, LINERD, FDLINT, MATVEC, FLDCOV, FLDSPC, FLDHIS, CLSCOV, CLSSPC, CLSHIS, MULSPC, and SETMRG.

A.2.2 Interfaces

LEARN references the STBASE, GLOBAL, COMBK4 and ISOLNK common blocks.

A.2.3 Inputs

The calling sequence to LEARN remains unchanged.

A.2.4 Outputs

There is no new line printer output from LEARN.

A.2.5 Storage Requirements

TBD

A.2.6 Description

The modifications to be made to the subroutine LEARN are to test the sun angle (SAKEY) and filter (FKEY) flags.

If the SAKEY flag is on (SAKEY = 1), the following will take place:

a. Test the flag ISUNT. If ISUNT is on (ISUNT = 1), the sun angles that relate to the B-Matrix channels will be read from the data tape. If ISUNT is off (ISUNT = 0), the sun angle were read in SETUP1. The sun angles will be used in the sun angle correction process.

b. The subroutine PCSUNF will be called to output the sun angle bias and gain correction factors.

c. The sun angle correction factors (bias and gain) will be applied to the raw data vectors before calculating the mean and covariance matrix.

If the filter flag (FKEY) is equal to:

a. Zero - the raw or sun angle corrected data vectors will not be filtered before calculating the mean and covariance matrices.

b. One - the 'Water' filter will be applied to the raw or sun angle corrected data vectors before calculating the mean and covariance.

The data vector will be filtered if one of the following holds:

1. $X_1 - \frac{t(1)}{t(2)} (X_2) \geq 0$ and $X_2 \leq t(2)$

where X_i = the radiance value of the f_i component of the current data vector.

f_i = the $i^{\underline{th}}$ channel value read from the FILTER parameter section of the CHANNELS control card.

t_i = the i^{th} user-supplied (the i^{th} parameter read off of the THRESHOLD control card) or default (t_1 = 43.0, t_2 = 12.0) threshold value.

c. Two - the Tassel Cap filter will be applied to the raw or sun angle corrected data vectors before calculating the mean and covariance matrices.

The following transformation will be applied to each data vector before it is filtered:

$$\vec{Y} = \begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \end{pmatrix} = K\,\vec{X} + \vec{b}$$

where $\vec{Y}$ = transformed raw or sun angle corrected data vector,

K = the matrix input via cards or via the file, BMFILE,

$\vec{X}$ = The $f_1 \rightarrow f_4$ components of the raw or sun angle corrected data vector, and

$\vec{b}$ = the user - supplied or default (b_i = 0.0) additive bias vector.

The data vector will be filtered if one of the following holds:

1. $Y_1 > t_1$
2. $Y_2 < t_2$
3. $Y_3 < t_3$
4. $Y_4 < t_4$
5. $Y_4 > t_5$

The default threshold values are t_1 = 100.0, t_2 = 8.0, t_3 = 6.0, t_4 = 10.0, and t_5 = 35.0.

A.2.7 Flowchart

N/A

A.2.8 Listing

TBD

APPENDIX B

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B.1 SOFTWARE SUBPROGRAM NO. 1 (DATATR)

The driver program for the Data Transformation processing, DATATR, will be modified to optionally generate an nxn unitary matrix PCM when the PCGC flag is on. The PCM matrix will be used in the generation of the Principal Component Greenness (PCG) Image.

B.1.1 Linkages

DATATR is called by the LARSYS executive program, MONTOR.

The following subroutines may be called by DATATR: SETUP8, SETREM, KBTRAN, MAXMAT, TRHIST, LNTRAN, MTMLS6, MTMDAT, and the new subroutines GETGCV and PCMMAT.

B.1.2 Interfaces

DATATR references the INFORM, TRBLCK, and GLOBAL common blocks.

B.1.3 Inputs

The calling sequence to DATATR remains unchanged.

B.1.4 Output

If the column dimension of the 'B-MATRIX' is not equal to the row and column dimensions of the data covariance matrix Σ_x read from SAVTAP, the following error message will be output:

'THE DIMENSION OF BMAT XXX AND DCOV XXX ARE NOT COMPATIBLE - CALL EXIT'.

B.1.5 Storage Requirements

TBD

B.1.6 Description

The following modifications will take place only if the PCGC flag is on (i.e., the OPTION PCG control card was read in SETUP8):

a. The subroutine GETGCV will pull the data covariance matrix Σ_x off of the SAVTAP. This covariance matrix will have been calculated from filtered raw or sun angle corrected data vectors depending on the 'OPTION' and 'SUNANG' control cards input by the user during the STAT processor mode.

b. Before the mixture covariance matrix of the Green Image bands (Σ_G) is to be generated, the row and column dimensions (the row and the column dimensions should be equal) will be checked against the column dimension of the B-MATRIX. If these dimensions are not equivalent, the error message stated in the Output section 3.2.1.4 will be printed.

c. The subroutines MTMLS6 and MTMDAT will generate the GCOV matrix.

$$\Sigma_G = B \quad \Sigma_x \, B^T$$

where Σ_G = mixture covariance matrix of the Green Image bands,

B = Transformation matrix in which each row contains the greenness vector. The matrix is to be input in the 'B-MATRIX' format,

Σ_X = The optionally filtered data covariance matrix to be used in the PCG transformation will be read off of SAVTAP, and

B^T = the transpose of B.

d. The subroutine PCMMAT will be called to operate on the matrix Σ_G. The program will in turn return an nxn unitary matrix PCM. The PCG Image will then be generated by applying the PCM matrix to the Green Image.

B.1.7 Flowchart

N/A

B.1.8 Listing

TBD

B.2 SOFTWARE SUBPROGRAM NO. 2 (SETUP8)

The modifications to subroutine SETUP8 will result in the reading and decoding of the following additional and modified control cards:

a. TRFORM OUTPUT/UNIT=n, FILE=m
b. SUNANG n_1, $n_2 \ldots n_j$
c. OPTION GREEN
d. OPTION PCG

The following flags will be set and used in the other subprograms. They will be added to the labeled common block, TRBLCK.

a. PCF - flag indicating 'OPTION GREEN' and/or 'OPTION PCG' control card was read in.
b. SAKEY - sun angle key - if on, apply the sun angle gain, SAGAIN and sun angle bias, SABIAS correction factors obtained from the subroutine PCSUNF.
c. PCGC - flag indicating 'OPTION PCG' control card was read in.
d. GIC - flag indicating that the 'OPTION GREEN' control card was read in.

The following variables will be added to the common blocks TRBLCK and GLOBAL to be referenced by the other subprograms:

a. SAGAIN - sun angle gain correction factor.
b. SABIAS - sun angle bias correction factor.
c. TRNSFL - the file number that the output transformed data is to be output on (default = 1).

B.2.1 Linkages

SETUP8 is called by the driver program for Data Transformation, DATATR. SETUP8 in turn calls the NXTCHR, FIND, BMFIL, NUMBER, ORDER, FLTNUM, CRDSTA, and WRTBM routines. If sun angle correc-

tions for the Green Image and/or PCG Image Transformations were requested, a call will be made to the new subroutine, PCSUNF.

PCSUNF will return the set of sun angle gain and bias correction factors to be used on each data channels input.

B.2.2 Interfaces

SETUP8 references the following common blocks: INFORM, GLOBAL, ISOLNK, and TRBLCK.

B.2.3 Inputs

The calling sequence to SETUP8 remains unchanged.

- NEW CONTROL CARDS

Keyword (col. 1)	Parameter (col. 11-72)	Function
OPTION	Green (Default - Green Image not generated for output)	The Green image will be generated and output.
OPTION	PCG (Default - no Principal Components Green Image output)	The PCG Image will be generated and output.
FORMAT	UNIVERSAL (Default - Universal)	The transformed data will be output in the Universal format.
FORMAT	LARSYS (Default - Universal)	The transformed data will be output in the LARSYS II format.

Keyword (col. 1)	Parameter (col. 11-72)	Function
SUNANG	Tape (Default - no sun angle correction applied)	Sun angles will be extracted from the ERIPS "unload" MSS image tape.
SUNANG	$n_1, \ldots, n_j$ (Default - no sun angle correction applied	n_i=sun angle for pass i, $1 \leq i \leq 8$. Sun angles are integer numbers, $5 \leq n_i \leq 85$.
TRFORM	OUTPUT/UNIT=N, FILE=M (Default - N=14 M=1)	N = the tape's Fortran logical unit number that the new image of transformed data is to be output on. M = the file number that the new image is to be output on. If both Greenness and PCG are requested, the former image will be output on file M and the latter image on file (M+1).

B.2.4 Outputs

Modification to SETUP8 will include the addition of the following error message:

a. If the B-MATRIX input flag BMTRIG is not on (=1), the error message will be:

'The B-MATRIX CONTROL CARD WAS NOT FOUND - TERMINATE EXECUTION'.

The line printer output will continue to list the (new) control cards read in by SETUP8.

B.2.5 Storage Requirements

TBD

B.2.6 Description

The function of SETUP8 is to read and decode all of the input processor control cards as well as their parameters. The following modifications will be made:

a. The user will be able to specify on the new 'TRFORM' control card which unit number (default = 14) and file number (default = 1) are to be used for the output transformed image tape.

b. The user will be given the option of using raw or sun angle corrected data vectors in the transformation process depending on the presence or absence of the SUNANG control card. If the SUNANG control card was read in, the input 'MAXPT' vector will be sun angle corrected.

c. The user has the option of creating a Green Image and/or Principal Component Greenness (PCG) Image.

d. The transformed data will be output in the Universal format unless the LARSYS parameter is found on the FORMAT control card.

e. If the Green Image and/or PCG Image is to be generated, the maximum dimension allowed for B-MATRIX is (n,n*k), where k = number of channels per pass and n = the number of passes and $n^2*k \leq 400$. The default number of channels per pass (NCHPAS) is equal to 4. NCHPAS is set in the BLKCOM subroutine and included in the GLOBAL common block.

B.2.7 Flowchart

N/A

B.2.8 Listing

TBD

B.3 SOFTWARE SUBPROGRAM NO. 3 (KBTRAN)

The subroutine KBTRAN will be modified to test the new flag:

a. SAKEY - when it is on (SAKEY = 1), the channel-oriented sun angle correction bias and gain factors (obtained from the subroutine PCSUNF) will be applied to the respective channel component of the mean vector and covariance matrix obtained from the subclasses statistics file, SAVTAP.

B.3.1 Linkages

Subprogram KBTRAN is called by the Data Transformation driver program, DATATR when rescaling by the statistical method is requested by the user. KBTRAN calls the following subroutines: MATVEC, MTMLS6, MTMDAT, and PRTCOV.

B.3.2 Interfaces

The common blocks referenced by the KBTRAN subprogram are: INFORM, TRBLCK, GLOBAL, and COMBK4.

B.3.3 Inputs

The calling sequence for KBTRAN remains unchanged.

B.3.4 Outputs

If the SAKEY is on:

a. The SAVTAP's mean vectors will be transformed using the sun angle correction factors, SAGAIN and SABIAS. The formula used is:

$$TM(I) = SAGAIN(I) * M(I) + SABIAS(I),$$

where TM(I) = Ith component (channel) of the sun angle corrected transformed mean vector,

SAGAIN(I) = Ith sun angle gain factor that relates to the Ith channel,

M(I) = Ith component (channel) of the mean vector from SAVTAP, and

SABIAS(I) = Ith sun angle bias factor that relates to the Ith channel.

b. The appropriate sun angle correction factors will be applied to the SAVTAP's covariance matrix, Σ_x, before transforming it to $B \Sigma_x B^T$, where B is the 'B-MATRIX' which contains the Kauth Greenness Vectors, and B^T is the transpose of B. The formula used on each component of Σ_x is:

$$TCOV(I,J) = SAGAIN(I) * SAGAIN(J) * COV(I,J)$$

where TCOV(I,J) = sun angle corrected transformed (I,J)th component of the SAVTAP's covariance matrix Σ_x, I,J = 1, . . . , NOFEAT,

SAGAIN(I) = Ith sun angle gain factor that relates to channel I.

SAGAIN(J) = J-th sun angle gain factor that relates to channel J, and

COV(I,J) = (I,J)th component of the SAVTAP's covariance matrix.

B.3.5 Storage Requirements

TBD

B.3.6 Description

If the SAKEY flag is on, the sun angle correction bias and gain factors will be applied to the corresponding component of the SAVTAP mean vector and covariance matrix.

If the PCGC flag is on (i.e. the 'OPTION PCG' control card was read in SETUP8), the matrix PCM (output from the PCMMAT subroutine) will be applied to the calculated Green Image's MAX_G (=MAX), MIN_G(=MIN), and CON_G(=CON) vectors to obtain the PCG

Image's scaling parameters, MAX_P, MIN_P, and CON_P.

The PCG Image's

a. MAX_P vector (PCM * MAX_G) will be stored in locations BMAT (401) → BMAT (401 + LCOMB-1).

b. MIN_P vector (PCM* MIN_G) will be stored in locations BMAT (401 + LCOMB) → BMAT (401 + 2 * LCOMB-1).

c. CON_P vector (PCM * CON_G) will be stored in locations BMAT (401 + 2 * LCOMB) → BMAT (401 + 3 * LCOMB-1).

B.3.7 Flowchart

N/A

B.3.8 Listing

TBD

B.4 SOFTWARE SUBPROGRAM NO. 4 (TRHIST)

The following modifications to TRHIST will be performed if the PCGC flag is on (i.e. the 'OPTION PCG' control card was read in SETUP8):

a. The scaling parameters, MAX, MIN, and CON, obtained from the histogram of the transformed data will be multiplied by the PCM matrix. The resulting vectors will be the PCG Image's scaling parameters, AMAX, AMIN, and ACON.

b. The PCG Image's scaling parameters will be stored in BMAT's scratch storage locations: BMAT (401) → BMAT (401 + 3 * LCOMB-1).

B.4.1 Linkages

The driver program DATATR calls TRHIST when the user specifies rescaling by the histogram method.

TRHIST calls the following subroutines: LAREAD, TAPHDR, SQRT, FLDINT, LINERD, FDLINT, TRANSF, and MATVEC.

B.4.2 Interfaces

TRHIST references the following common blocks: INFORM, TRBLCK, COMBK4, and GLOBAL.

B.4.3 Inputs

The calling sequence to TRHIST remains unchanged.

B.4.4 Outputs

There is no line printer output.

B.4.5 Storage Requirements

TBD

B.4.6 Description

TRHIST will obtain the scaling parameters, MAX, MIN, and CON for the transformed data from the histogram of the transformed data of the first field of a set of fields.

If the PCGC flag is on (i.e. the 'OPTION PCG' control card was read in SETUP8), the matrix PCM (output from the subroutine PCMMAT) will be applied to the Green Image's scaling parameters MAX_G (=MAX), MIN (=MIN), and CON_G (=CON).

The PCG Image's scaling parameters:

a. MAX_P (PCM * MAX_G) will be stored in locations BMAT (401)→ BMAT (401 + LCOMB-1).

b. MIN_P (PCM * MIN_G) will be stored in locations BMAT (401 + LCOMB) → BMAT (401 + 2 * LCOMB-1).

c. CON_P (PCM * CON_G) will be stored in locations BMAT (401+ 2 * LCOMB) → BMAT (401 + 3 * LCOMB-1).

B.4.7 Flowchart

N/A

B.4.8 Listing

TBD

B.5 SOFTWARE SUBRPOGRAM NO. 5 (PCMMAT)

The new subroutine PCMMAT was originally programmed for execution under EXEC8 by W. L. Morris, C. L. Wiginton, and D. K. Lowell (University of Houston Mathematics Department). The revised subroutine will be incorporated in the Data Transformation subroutine PCMMAT. PCMMAT operates on a real symmetric matrix A to produce an orthogonal matrix of approximate eigenvectors of A. For the Principal Component Greeness (PCG) transformation, the symmetric matrix will be the mixture covariance matrix of the green bands (Σ_G) and the output orthogonal matrix will be PCM. The n x n (n = LCOMB = row dimension of Σ_G) unitary matrix PCM will have its ith row correspond to the ith largest normalized eigenvector of Σ_G. The resulting components of PCM will be approximate eigenvalues (i.e. the error bounds will be between $\pm$ 0.000005) of Σ_G. In the present context,

$$\Sigma_G = B \, \Sigma_x B^T$$

where Σ_G = mixture covariance matrix of the green bands.

B = BMAT = matrix in which each row contains the greenness vector.

Σ_X = the filtered raw or sun angle corrected data covariance matrix calculated in STAT.

B.5.1 Linkages

PCMMAT will be called by DATATR.

PCMMAT will reference the following internal subroutines: MINDEX, ORDER, SUPSUM, and MATMUL.

B.5.2 Interfaces

PCMMAT will not reference any common blocks. The interface with the calling program is by means of the calling sequence.

B.5.3 Inputs

The callings sequence to PCMMAT is:

Call PCMMAT (A, PCM, C, R, N)

Parameter	Dimension	In/Out	Definition
A	(N,N)	IN	A symmetric real matrix (for PCG transformation processing, A=Σ_G, the mixture covariance matrix of the green image bands).
PCM	(N,N)	OUT	An unitary orthogonal matrix of normalized eigenvectors of A.
C	N	OUT	Vectors of centers of Weinstein discs.
R	N	OUT	Vector of radii of Weinstein discs.
N	1	IN	The row and column dimension of A (for Σ_G, N=LCOMB=number of LANDSAT Passes).

B.5.4 Outputs

The orthogonal unitary matrix PCM will be returned to the calling subroutine DATATR, via calling argument.

B.5.5 Storage Requirements

TBD

B.5.6 Description

PCMMAT proceeds through an iterative algorithm to produce the

output orthogonal matrix PCM. PCM, which is composed of approximate eigenvectors of Σ_G will call the following internal subroutines:

a. MINDEX - selects the order of operations within PCMMAT.

b. ORDER - reorders the components of the input vector into ascending order.

c. SUPSUM - add the components of the reordered vector from ORDER.

d. MATMUL - computes the matrix products.

The relative error allowed in the approximate eigenvalues of Σ_G will be set to 0.000005.

B.5.7 Flowchart

TBD

B.5.8 Listing

TBD

B.6 SOFTWARE SUBPROGRAM NO. 6 (TRANSF)

The calling sequence to TRANSF will be modified to exclude the XT variable. TRANSF will be changed from a subroutine to a function. The internal variable XT will be set equal to TRANSF. The flag SAKEY will be tested to determine if the input raw data vector, IDATA is to be sun angle corrected before performing th ata transformation calculation.

B.6.1 Linkages

TRANSF is called by either the subroutines TRHIST and/or LNTRAN. TRANSF does not call any subroutine.

B.6.2 Interfaces

TRANSF refers to the TRBLCK common block.

B.6.3 Inputs

The calling sequence to TRANSF is:

- XT(J)=TRANSF (BMAT, IDATA, TOP, IL, K, LCOMB, NSAMP, BIAS).

Parameter	Dimension	In/Out	Definition
BMAT	480	IN	The matrix, which is stored in the 'B-MATRIX' format, to be used in the transformation process.
IDATA	TOP	IN	The input raw data vector to be transformed.
TOP	1	IN	The maximum usable location in the array IDATA.
IL	1	IN	The component of the transformed data vector that will be generated.

Parameter	Dimension	In/Out	Definition
K	1	IN	The current sample pixel being processed.
LCOMB	1	IN	The number of linear combinations or passes to be used in the calculation.
NSAMP	1	IN	The number of sample data vectors to be transformed.
BIAS	16	IN	The bias vector to be used in the data-transformation process.

B.6.4 Outputs

There is no line printer output. The value of the IL-th component of the transformed data vector (XT) will be returned in the function name TRANSF.

B.6.5 Storage Requirements

TBD

B.6.6 Description

The flag SAKEY will be tested in the function TRANSF to determine if the input raw data vector is to be sun angle corrected or not. If the flag was turned on (i.e. SAKEY = 1), the following transformation will take place before the existing data transformation process:

$$TDATA = SAGAIN(I) * IDATA(L) + SABIAS(I)$$

where TDATA = the sun angle corrected I-th channel component of the current data vector,

SAGAIN(I)= the sun angle gain correction factor for the I-th channel,

IDATA(L)= the I-th channel component $\left(\frac{L}{NSAMP+1} + 1 \right)$ of the current data vector,

NSAMP = the number of sample data vectors (for the current scan line) that needs to be transformed, and

SABIAS(I)= the sun angle bias correction factor for the I-th channel.

If the SAKEY was not on (i.e. SAKEY = 0), the raw data vector, IDATA will be used in the data transformation formula:

XT = IDATA * BMAT + BIAS

If the SAKEY was turned on (i.e. SAKEY = 1), the sun angle corrected data vector, IDATA will be used in the transformation formula:

XT = TDATA *BMAT + BIAS

Before returning to the calling subroutine, TRANSF will be set equal to XT.

B.6.7 Flowchart

N/A

B.6.8 Listing

TBD

B.7 SOFTWARE SUBPROGRAM NO. 7 (LNTRAN)

The modifications to be made to the subroutine LNTRAN will enable the user to generate and output a 'Green' and or 'Principal Component Greenness' (PCG) Image. The decision on whether these images are to be generated and output will depend on the new flags PCGC (turned on when the OPTION PCG control card was read in SETUP8) and GIC (turned on when the OPTION GREEN control card was read in SETUP8).

B.7.1 Linkages

LNTRAN may call the following subroutines: TAPHDR, LAREAD, FLDINT, WRTHDR, LINERD, FDLINT, TRANSF, WRTLIN, NTRAN, COMHST, and MATVEC.

LNTRAN is called by the driver program of Data Transformation, DATATR.

B.7.2 Interfaces

LNTRAN will make reference to the following common blocks: INFORM, TRBLCK, COMBK4, and GLOBAL.

B.7.3 Inputs

The calling sequence to LNTRAN remains unchanged.

B.7.4 Outputs

The user will be able to generate and output a Green and/or PCG Image depending on the value of the flags GIC and PCGC.

The transformed data set will be output on the default (Fortran Unit 14, file=1) or user-specified tape unit and file number.

B.7.5 Storage Requirements

TBD

B.7.6 Description

If the GIC flag is on (GIC=1), the scaling parameters MAX, MIN, and CON derived from the histogram of the 'Green Image' will be used in the transforming, rescaling, and histogramming processes of the data vectors.

If the PCGC flag is on (PCGC=1),

a. The scaling parameters (derived from the histogram of 'PCG' Image) stored in locations BMAT (401) → BMAT (400 + 3 * LCOMB) will be used in the processes of transforming, rescaling, and histogramming the data vectors. Recall that the MAX vector is stored in locations BMAT (401) → BMAT (400 + LCOMB). The MIN vector in locations BMAT (401 + LCOMB) → BMAT (400 + 2 * LCOMB), and the CON vector in locations BMAT (401 + 2 * LCOMB) → BMAT (401 + 3 * LCOMB).

b. The matrix PCM will be applied to the transformed data vectors output from the subroutine TRANST.

B.7.7 Flowchart

N/A

B.7.8 Listing

TBD